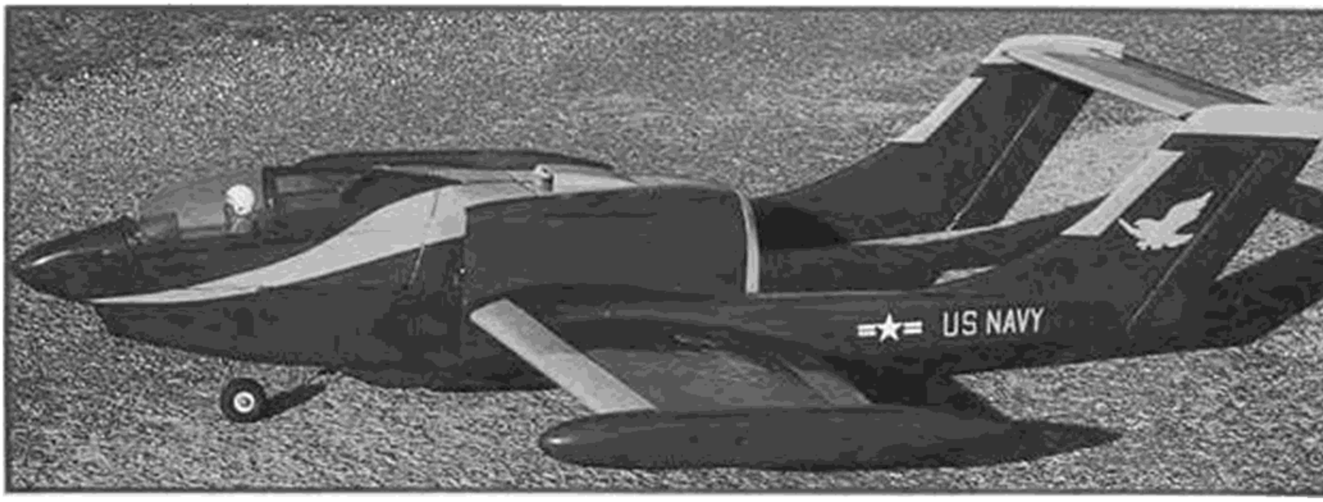
EAGLE MK. II



Looks, performance, and all wood construction make this model a natural for your first ducted fan.

By Giancarlo Genta

The whole thing started in December '87, when my son Alessandro (then 11) was learning to fly with the usual trainers. He asked me to build a jet plane which would be easy enough for him to fly and still retain the "jet fighter" looks and performance one looks for in a model of this kind.

The idea was so challenging that I decided it was worth giving it a try.

In our city there are a number of modelers who fly Pulsejet aircraft. They are impressive and well suited for air shows but their noise, the need of complex (perhaps simply unusual for the average modeler) starting procedures, and the impossibility of regulating the thrust in the usual way are not exactly what a "Sunday Flier" likes as a standard flying machine.

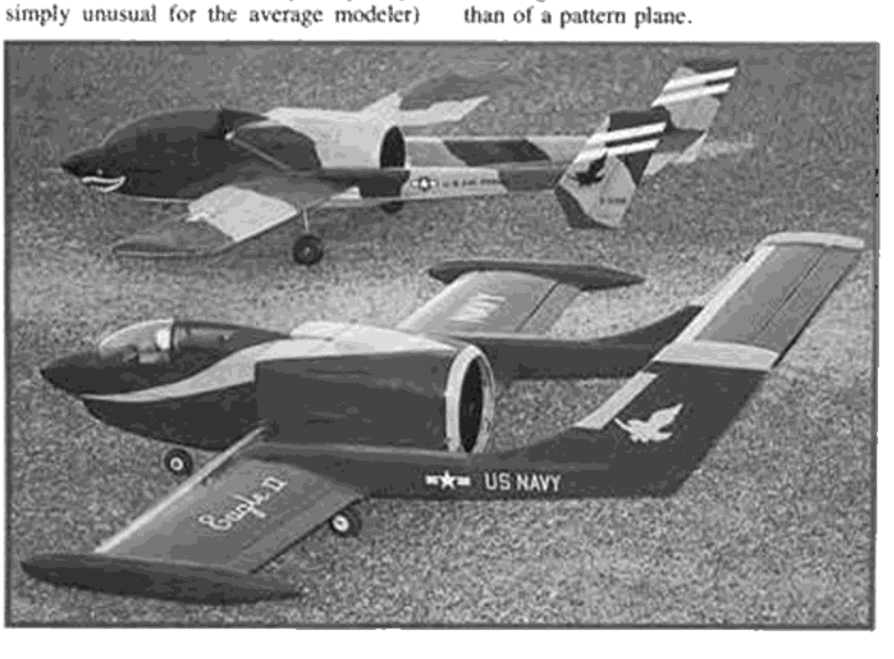
Ducted fan propulsion seemed to be much more promising. I had never seen a ducted fan plane flying, although I knew that in our area some modelers had one in the building stage. The president of our club had a number of flights with a Byron F16 and was building a Corsair II with the same Byrojet unit.

I started looking in magazines to see whether it was possible to find a model which would fit the idea I had of an "entry level" ducted fan.

The basic requirements were:

1. The ship had to be easy to fly, with handling characteristics more like a trainer than of a pattern plane.
2. Good take off characteristics, without the need of a long, surfaced runway.
3. Ease of operation, particularly the starting of the engine. The model had to have more or less the same ease of handling a Sunday Flier expects from his planes.
4. Overall look of a jet fighter. If not a scale model of an actual jet, it had to at least look like a real aircraft. No cheater hole allowed!
5. Good speed performance, possibly in the range of 130 mph (200 km/h).
6. Very good maintainability, with easy access to the engine and all other devices needing maintenance.
7. Ease of construction with conventional materials and scratch-building techniques, with low cost for the whole project as a secondary requirement.

I realized that no ducted fan kit or drawing I was aware of would fulfill the above mentioned requirements.

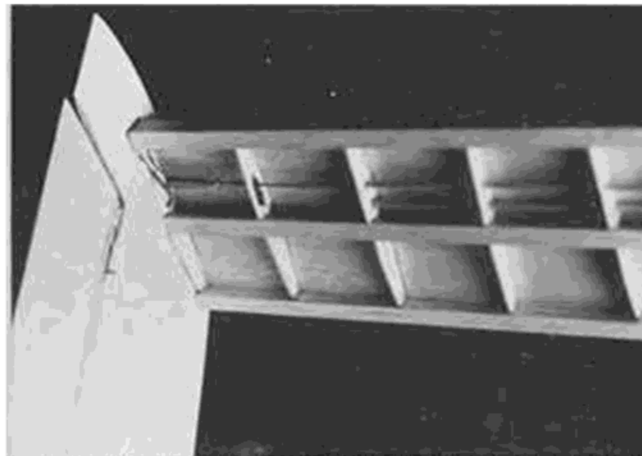


Even though ducted fans are suitable for scale models (as many jet scale aircraft have been built with success), only by designing a flying machine around the propulsion unit can you optimize its performance and fulfill completely the above mentioned requirements.

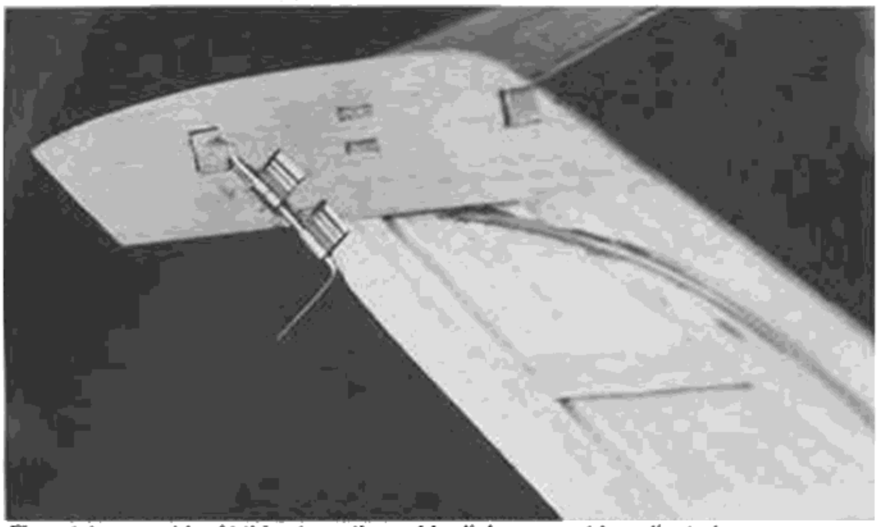
I bought a Byrojet unit, a secondhand Rossi 81, which had just been run in, with the pipe suited for the application and a retract set. And after measuring all the relevant dimensions, I started drawing.

A twin boom configuration was chosen in order to keep the duct short, lower the weight, and make the accessibility to the engine as easy as possible. Large air intakes were provided and an auxiliary intake to cool the pipe was used. Another auxiliary intake to cool the engine head was added later.

It took me about four months to design



LEFT: Right fin before covering, seen from the outside. Note the elevator flexible control cable. RIGHT: Assembling the left fin to the stab, before bottom sheeting is added.



Fins-stab assembly. At this stage, the rudder linkage must be adjusted.

Parts for assembling boom.

this first ship and about eight months were needed to build it, including building a wing with a matching airfoil and similar techniques and then testing it on a trainer fuselage. The fuselage, wing, and tail are all plywood and balsa.

At the end, I had a jet plane with a span of 62'', a length of 54¼'', and a weight of 183 ozs. (11 lbs. 7 ozs.).

A 7-channel JR FM radio was used in the first prototype model, with all channels working (air retracts, flaps, and mixture control on the additional channels). The steering had to be driven by a separate servo, operated by the rudder channel.

The plane was given the name "Eagle" with a general look of a military ship.

I machined a starter extension and on the first Saturday of January '89, everything was ready.

I had never seen a ducted fan plane up close, so when the starter was applied and the engine roared, I really was amazed: I would have never thought such a thrust (and such a scream) possible. The "test pilot" of our club took the controls, all checks were made and the plane was released. It took about 30m to get airborne, climbing at 45°. When the plane was leveled off, it was clear that the performance exceeded any expectation.

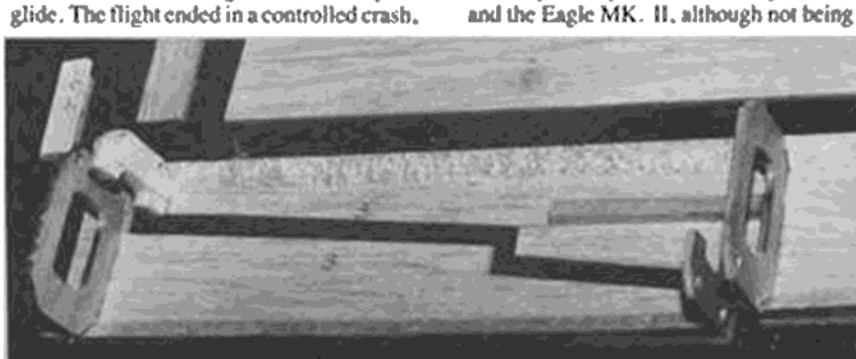
It really "flew off the drawing board," as the saying goes. It could climb vertically out of sight and the horizontal speed has been judged in the range of 120-140 mph. The general behavior and the way it performs basic aerobatics is that of a jet fighter.

However, on the very first flight a bad characteristic of the design was evident. After about 10 minutes into the flight the engine quit in a high speed low altitude fly-by. It was clear that the elevator, without the blast of the fan and in the aerodynamic shade of the fuselage, loses most of its authority. The plane cannot assume the correct angle for a low speed glide. The flight ended in a controlled crash, without much damage.

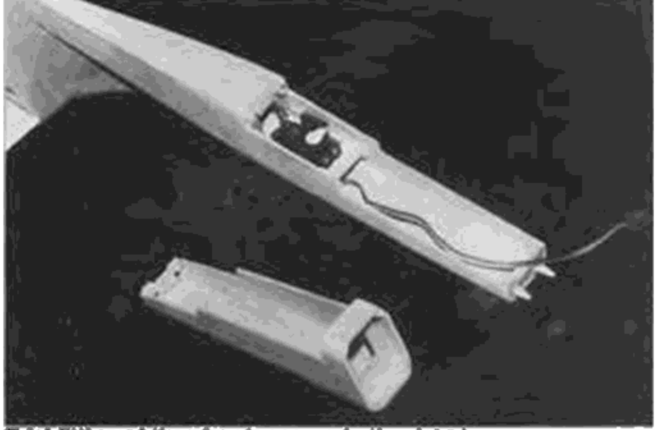
In the subsequent flights, we learned that by properly using the flaps it could be made to glide safely to a dead stick landing, but the engine off performance remained marginal.

The desire to correct this bad characteristic and to improve the already very good flight performance drove me to the drawing board again to design a second version of the plane.

The main change was to move the stab to a position in which it would retain its authority even with the engine off. Actually, this proved to be very effective and the Eagle MK. II, although not being a

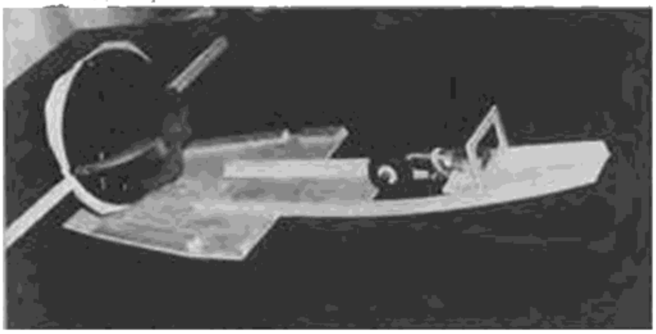


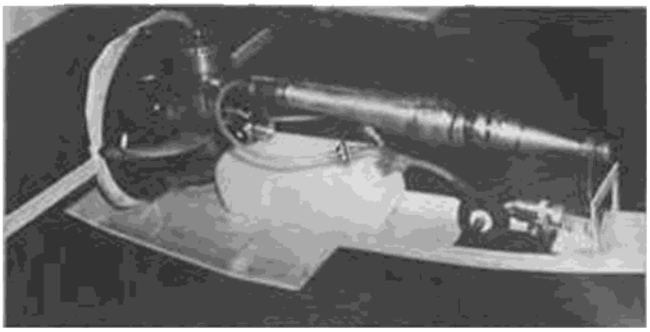
Details of formers F8 and F9.



Trial fitting of the elevator servo in the right boom.

Elevator linkage on the right fin.





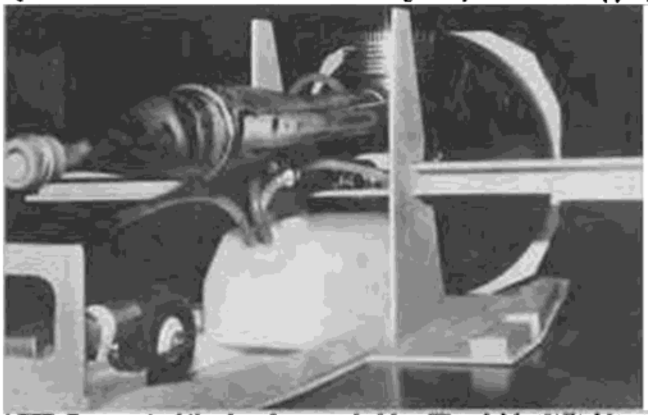
***LEFT:** Bottom of the fuselage with former F6 and landing gear plate installed. Trial fitting of the fan unit and of the front leg of the undercarriage. **RIGHT:** Close-up of the fan, engine, pipe, and tank installation.*

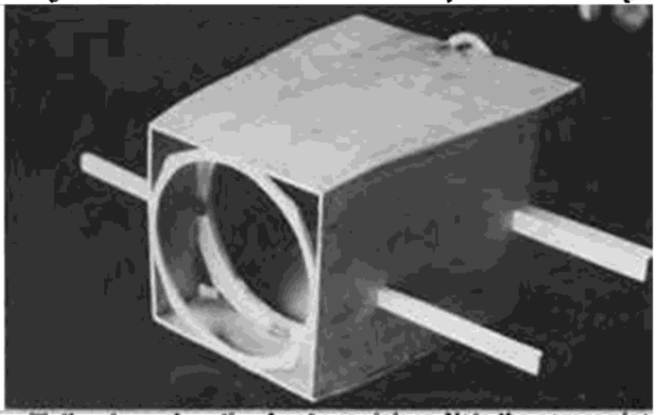
floater, glides in a way I never thought possible for a model with such a high wing loading. Dead stick landings are no longer a problem

Other changes were meant to keep the weight low, with a goal of 8.5 lbs. (which again was not achieved) to reduce the drag and to increase the overall performances.

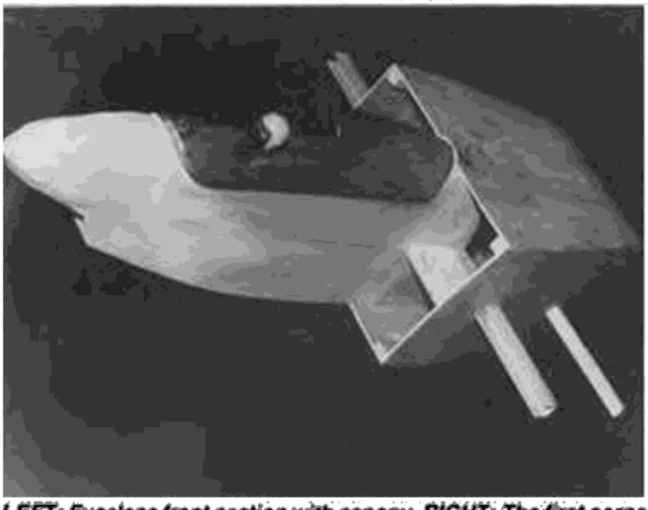
Attachments under the fuselage for different pods were provided. The modeler who plans to use this ship as an air show attraction can install different devices such as a release mechanism for bomb or parachute dropping, a drag chute, or a retractable arrester hook. A drag chute was tested with success and was quite spectacular and reduces the landing run substantially

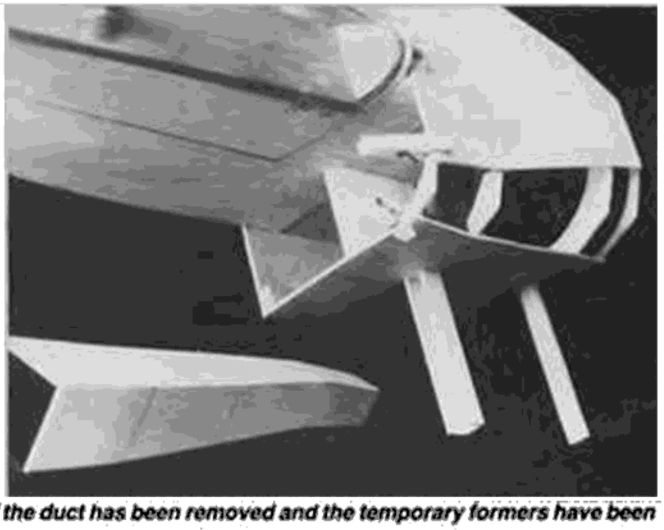
All design goals were met with ample margin. Both speed and maneuverability have been substantially increased, although





***LEFT:** Rear part of the fuselage pod sides (lite ply) installed together with the channel section front spar joiner. Note the corner pine strips on the duct. **RIGHT:** Fuselage rear section assembled and ready to be attached to front section.*





***LEFT:** Fuselage front section with canopy. **RIGHT:** The first corner of the duct has been removed and the temporary formers have been added. The corner is ready to accept the balsa planking.*

I cannot give any measured figure for the speed. We are waiting for a member of our club to finish an electronic speed meter in order to check whether the estimate of 155 mph (250 km/h) we timed is correct.

As the Eagle MK. II is not a model for true beginners, I will cover only some of the construction detail.

Tail Surfaces and Booms:

I usually start building from the tail feathers, so I can quickly see something finished before being fed up with the project. In this case, the twin fins are in one piece with the booms, and it is advisable to have the tail unit finished before gluing the wing to the fuselage in order to check all alignments.

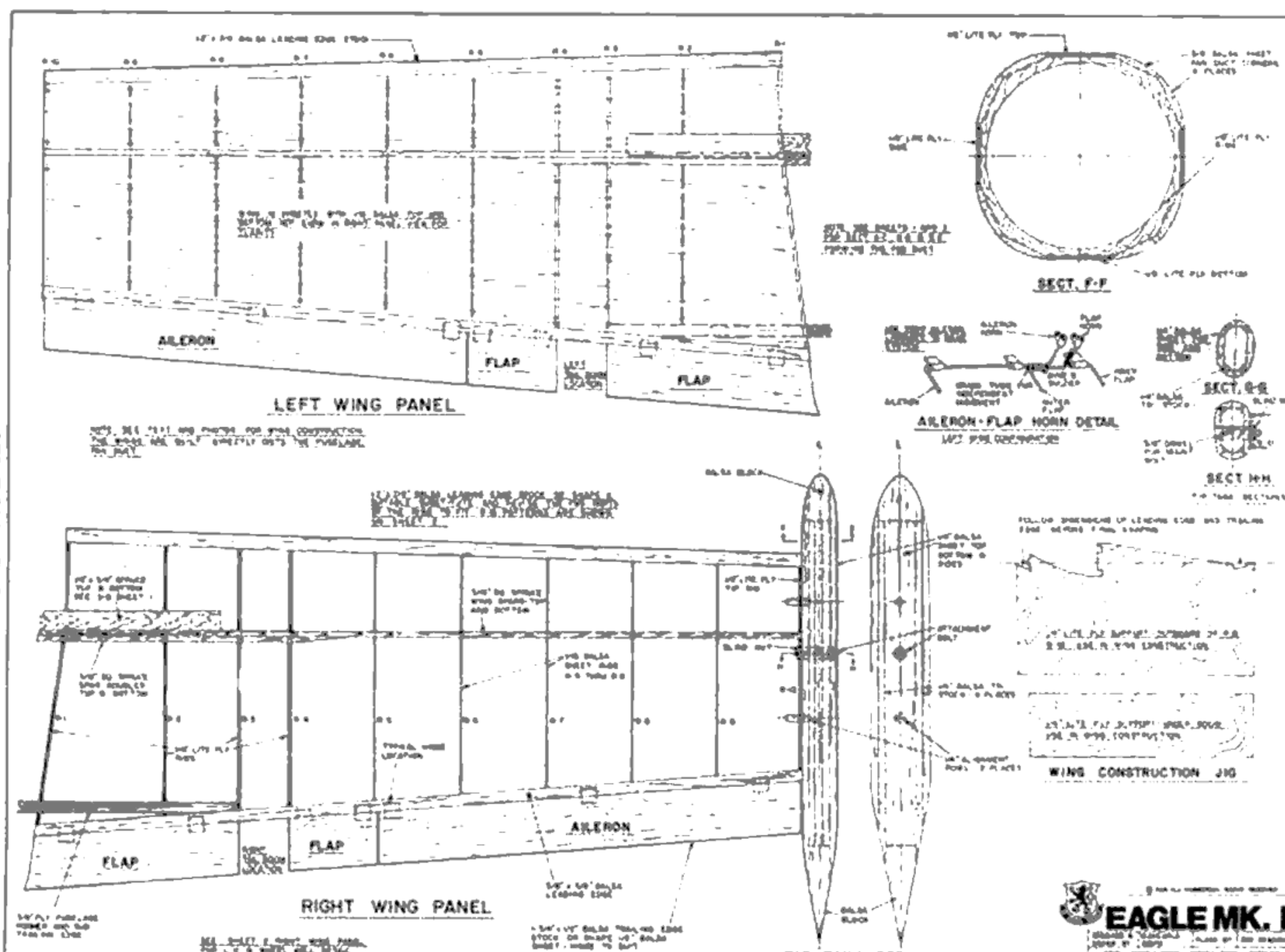
I usually do not cut all the pieces before I start assembling the structures. I cut just the parts needed for a subassembly and start building, so if design changes are needed I can proceed without discarding already cut parts.

Both rudders are actually working and I suggest not to simplify in this area. Both planes were saved by a strong rudder input when attempts to horse the ship from the ground (attempts to check how much STOL performance could be achieved) resulted in a tip stall and a beginning of a snap roll a few feet above the ground.

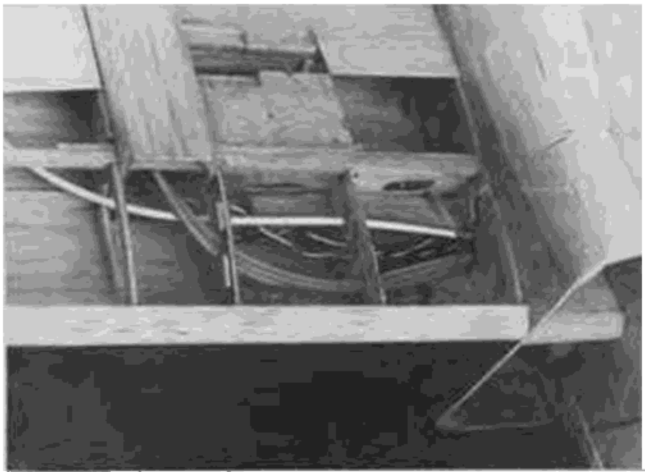
LEFT: The main structure of the right wing has been completed directly on the fuselage. Note the end and boom supports. RIGHT: Bottom of the left wing half planked.

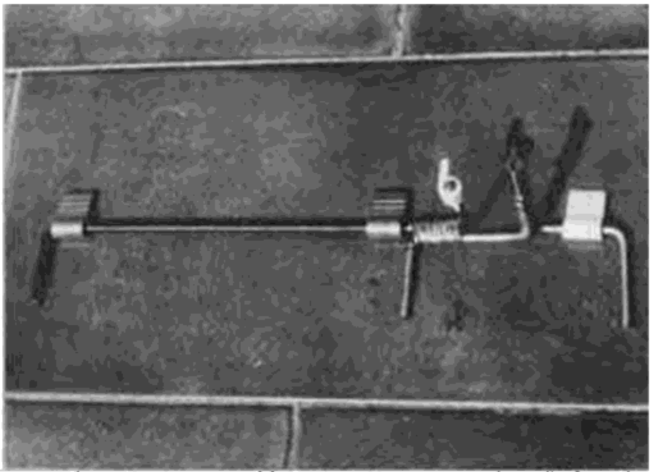
The left rudder is controlled in the usual way by the servo. A linkage made by two modified strip aileron hook-ups and by a flexible push-pull link running inside the horizontal stabilizer transfers the control from the left to the right rudder.

The drawing should be self-explanatory. In the photos there are two tubes shown through the ribs of the stab which is due to a design change after the front tube (now not used) was glued in. Only the rear tube is needed.



FULL SIZE PLANS AVAILABLE SEE PAGE 223





LEFT: Flexible controls, antenna tube, servo wires, and retract tubes seen from the bottom of left wing. Note retract installation; the wheel well will be cut later. RIGHT: Close-up view of the aileron-flap hook-up. The one shown is for the left wing.

First build the stab on a flat surface, using two square strips of wood for alignment of the ribs. Cover the upper surface using 1/16" balsa.

Then build the two fins, which are made with a core of 3/16" balsa covered by 1/16" balsa. Note the direction of the grain.

Start by gluing the inner covering to the core. Make the notch in the right fin for the elevator flexible control and glue it in place. Prepare the modified aileron linkages and assemble them in place. Prepare the notches to accommodate the spars of the stab, which must be flush with the core of the fin.

At this time, assemble the stab to the fins and hook up the rudder linkage.

Once you are sure that the steel rods which will enter into the rudder are parallel (I suggest using a pair of threaded clevises for adjustment as in the photo), put some glue on the clevises and you are ready for covering the bottom of the stab and the outer surfaces of the fins. To do this, you should pin the spars of the stabilizer to a flat surface.

The rudders and the elevator are made from conventional aileron stock and need no further description.

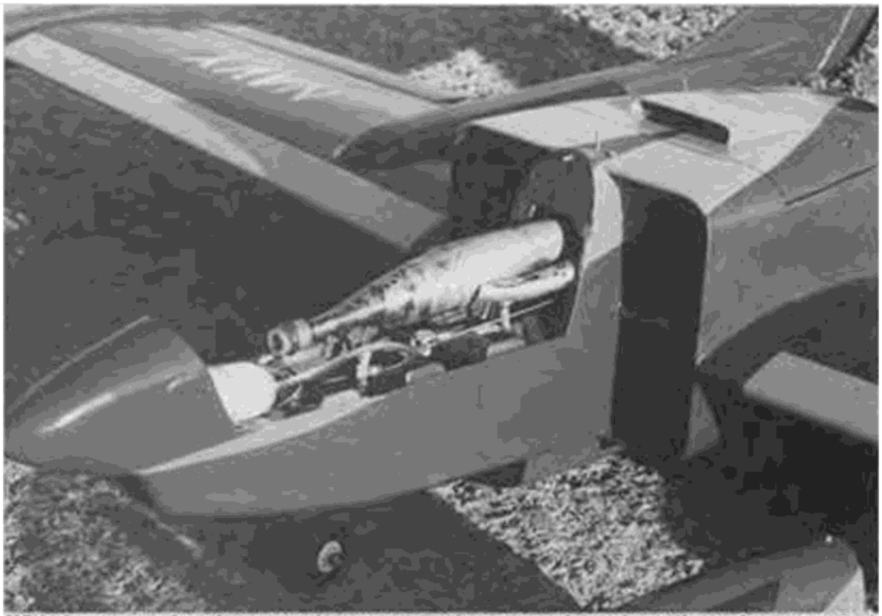
The booms are basically square boxes with triangular balsa strips at the inside corners. Each boom is in two pieces: a front part, which will be glued to the wing, and a rear part, which is a component of the tail unit. They must be built together in order to insure proper matching.

Start by cutting all pieces, including the four plywood formers F8 and F9 (2 for each boom) and the four matching plywood strips F8A and F9A. Each former and its corresponding plywood strip are cut and drilled (for the alignment dowels) together. Do not mix up the pairs.

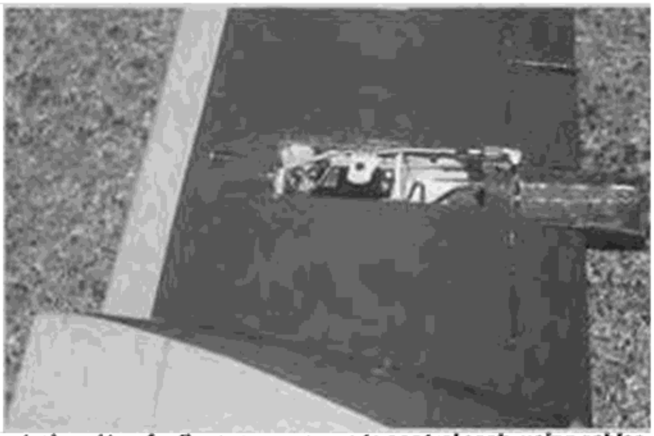
At this stage you cannot distinguish the right boom from the left.

The notches for the wing spars were made after assembling the booms. You can do them before, but then the two booms will be different due to the wing dihedral.

The servo rails are structural parts and



With the canopy/hatch removed, you can see the retract air bottle, radio equipment, tuned pipe, etc.



Aileron servo and flap control set-up. Can use two servos for aileron control, and two for flaps, or one servo to control each, using cables. See plans.

must be predrilled and assembled at this stage.

Cut the booms to accommodate the fins and assemble the whole tail unit.

At this stage the servos for elevator and rudders should be installed, the hinges put in place (not glued), and the whole control system should be thoroughly tested.

When everything is working properly, remove the servos, bellcranks, hinges, and moving surfaces, and shape the edges of the control surfaces and the corners of the booms.

Wait to cover and prime everything until the fit of the tail unit with the wing has been checked.

Fan Duct and Fuselage:

The fuselage is basically made up of two parts: the duct for the fan unit and a front pod which contains the receiver, four servos, batteries, the front leg of the landing gear, and the air tank.

The duct is built as a square box using lite ply. The four corners are then removed and the thick balsa planks are glued on and shaped. The hatch for access to the engine is cut later.

Start by pinning the bottom of the duct-pod assembly to the building board. Use shims in order to give the proper curvature to the front and the rear parts. As the rear part is quite stiff, make side-to-side cuts on the outer surface.

Add the balsa triangular corner pieces to the pod and some large pine (or any other wood — they will be removed later) corner pieces to the fan duct. Add the two formers F6 and F7 with the integral center section of the wing spars and the lite ply front part of the fuselage pod. Remember to drill the holes for flexible controls, the antenna, the servo wires, and the fan unit, and to glue the nuts in place at this stage.

You should now trial fit the fan unit, engine with pipe and fuel tank. The top and the sides of the duct are then added.

When everything is dry, cut a corner of the duct, fix the two removable formers with tape or any other means, and glue the balsa planking in place. Each corner is made using six pieces of planking.

When a corner is dry, remove the two formers and proceed to the following one until the duct is ready for shaping. Give a rough shape to the duct, at least in such a way that you can pin the whole thing to the building board again.

Add the formers for the front part and the landing gear plate (you could do this even before, as shown in the photos). Add the sides of the pod and the nose block.

Prepare the upper hatch with the canopy, available from Viking Models USA, 2 Broadmoor Way, Wylie, Texas 75098, (214) 442-3910.

The hatch is kept aligned by a sort of "rack" made of lite ply and is kept in position by a dowel in the front and a spring loaded latch in the back. I like to have very easy access to the inside and positioned the switch, air valve, charging plug, and fuel filling tube all inside the plane. When you open the hatch to get ready for a flight you can check, at least visually, that everything is all right.

Be careful when you fit the canopy and the hatch. It is hard to imagine the aerodynamic force upwards on the top of the fuselage when traveling at top speed. On the first flight of the Eagle I, the canopy was sucked upwards on the first high speed pass. On the Mark II plane, I took care to fit the canopy more safely, only to have the whole hatch assembly pulled from the rest due to a failure of the latch. Take care that the latch enters completely and is restrained from going backwards if not operated by hand. The solution shown in the drawing has not given any problems.

When the fuselage is sanded to shape (remember, to also shape the inside of the air intake), cut the recesses for the latches of the engine hatch and separate the hatch from the rest of the fuselage. Remember to trial fit the fan unit and the engine at this stage. They should enter through the hatch without too much trouble. The pipe and its adapter enter from the front hatch.

Cut the upper air intake and shape it. This additional intake was added after the first flights to the Eagle I and helped very much to keep the head of the engine cool.

Install the latches and the hinges. Remember that you will have to open the hatch for starting the engine and checking the fuel mixture. The latches have to be quite free, as you have to operate them under pressure (downward air pressure due to the fan and psychological pressure) when preparing for take-off.

Install the servo rails and trial fit everything.

In the first model, I was concerned about putting the pipe so near to the servos and the receiver, so I glued some of those temperature sensing self sticking tapes just under the pipe (in the first Eagle, all four fuselage servos were very near to the pipe). I made several flights with them, and the temperature never exceeded 150°F (65°C).

Wing:

The wing is more or less conventional. Prepare all ribs, remembering that in each wing there are four ribs of lite ply, the tip and root ribs, and those to which the landing gear plates are glued to.

Prepare the tip tanks at this stage, so you can drill the tip rib and glue the nut in place. I like to have them removable for ease of transportation and repair in case you scratch them on the runway.

Prepare the two pieces of the boom which must be glued to the wing by cutting the notches for the spars and landing gear plates. Glue the root ribs to the fuselage.

The half wings are built directly on the fuselage. Pin the fuselage and the wingtip spar support to the work surface. Also, pin the boom support in place at this time.

Glue the leading edge, trailing edge, and the lower spar in position and pin them to the tip support. Glue ribs #2 and #3 in place. Next, glue the landing gear plates, the front part of the boom and the rib #4 all in their proper locations.

Complete the wing structure with the other ribs, the upper spar, and the upper sheeting, before removing the whole thing from the building board.

Repeat the procedure with the other wing.

At this stage you should fit the control tubes for ailerons and flaps, the tube for the antenna, the servo extensions (I used JR 36" extensions), and the tubes for air retracts. I installed a pair of additional control tubes, in case in the future I want to install a device to drop something from the bottom of the booms.

Add the aileron-flap linkages, built as per the drawings, starting with two pairs of strip aileron linkage.

I chose to operate aileron and flaps using a single servo for each, through flexible controls instead of installing a servo in each

EAGLE MK. II

Designed By:
Giancarlo Genta

TYPE AIRCRAFT
Sport/Ducted Fan (Twin Boom)

WINGSPAN
62 Inches

WING CHORD
11 Inches (Avg.)

TOTAL WING AREA
682 Sq. In.

WING LOCATION
Mid-Wing

AIRFOIL
Root: NACA 64_2-215
Tip: NACA 64_1-112

WING PLANFORM
Tapered

DIHEDRAL, EACH TIP
3/4 Inch

OVERALL FUSELAGE LENGTH
54¼ Inches

RADIO COMPARTMENT SIZE
(L) 11" x (W) 3" x (H) 3½"

STABILIZER SPAN
22½ Inches

STABILIZER CHORD (incl. elev.)
6¼ Inches

STABILIZER AREA
142 Sq. In.

STAB AIRFOIL SECTION
NACA 63A010

STABILIZER LOCATION
Top of Vertical Fins

VERTICAL FIN HEIGHT
9½ Inches (2 Fins)

VERTICAL FIN WIDTH (incl. rud.)
7½ Inches (Avg.)

REC. ENGINE SIZE
.75-.90 DF 2-Stroke

FUEL TANK SIZE
24 ozs.

LANDING GEAR
Tricycle (Retractable)

REC. NO. OF CHANNELS
5-9

CONTROL FUNCTIONS
Rud., Elev., Throt., Ail.
Ret., Flaps, Mixture, Drag Chute

BASIC MATERIALS USED IN CONSTRUCTION

Fuselage/Booms	Balsa & Ply
Wing	Balsa & Ply
Empennage	Balsa
Wt. Ready To Fly	176 Ozs. (11 Lbs.)
Wing Loading	37.1 Oz./Sq. Ft.

wing. This is mostly due to the lack of space in the booms, but if you like, small servos can fit. At any rate, the system installed operated on both ships flawlessly and I see no need to change it.

When you are satisfied with the controls you can install the bottom wing skin and the two stub wings inside the air intakes to cover the controls.

It is now time to sand everything and check that everything works properly.

Finishing:

Try to keep the finishing as light as possible, particularly in the tail assembly.

The fan duct and the central part of the wing, up to the booms, are covered with fiberglass-epoxy for strength. Also, the inside of the fan duct is covered with fiberglass cloth and epoxy resin.

Do not forget to fiberglass the duct: actually it constitutes a very strong and stiff shell which transfers most of the flight stresses from the wing to the fuselage.

The outer part of the wing and the front part of the fuselage were covered as lightly as possible.

The model was painted in a sort of Blue Angels color scheme. Obviously, any scheme you like can fit, but remember that proper visibility in the air is of the utmost importance with a very fast model.

Radio:

A minimum of a 5-channel radio is needed as flaps are really useful. I used a 9-channel PCM radio, using all channels on my Eagle MK. II.

The remaining 4-channels were used for retracts, in flight mixture setting, steering, and drag chute. The steering servo can be driven by the rudder channel, but I like to have it on a separate channel mixed to the rudder in order to be able to adjust the travel and the centering independently.

With both the 7-channel FM and the 9-channel PCM, I never encountered problems with the servo extensions or the antenna running inside the model. At any rate, carefully check the operation of the system with the engine running at different speeds.

Flying:

The first flight of any model is a challenge, and for me the first flights of the two Eagles were great ones.

Even if the plane is very user-friendly, try to get the best pilot available at the controls for the first flights, particularly if you feel nervous.

Open the front hatch and fill the fuel tank, the air tank, and switch on the radio.

Start the engine with the upper hatch open and set the mixture. If you feel that this is dangerous, do not take chances, install an extension to the needle valve in order to operate it from the outside.

It may be necessary to unscrew the glow plug a turn or two in order to start the engine. (This is customary with racing boats.)

The engine was tached at 18,800 rpm static with a mechanical meter. This means that the meter and the hand of the user are in the exhaust duct and results in some decrease of the engine's performance. This also refers to the standard 20% oil, 8% nitro fuel. At any rate, the plane is so overpowered that even if you get lower engine rpm's, you should have little problem in attaining a safe flying speed.

When you are satisfied with the mixture, run the engine at full throttle and check the mixture in a nose down position. Remember that the engine is behind the tank, so you can have fuel draw problems in a nose down position. Check that the engine does not go too rich in a nose up position.

No fuel pump was used in either model, and I never encountered fuel draw problems. Actually, the fuel tank is very near to the carburetor and pipe pressure should be sufficient with any engine.

Check the radio with the engine running and test all systems. When all systems are go, cross your fingers and start the take-off run.

If the engine is properly tuned, the acceleration should be impressive. However, do not take chances, be ready to abort the take-off if you are not satisfied either with the acceleration or the directional control. After all, a full scale pilot would have to do so if things were not correct!

If everything is all right, let the plane get up to take-off speed. A slight pressure on the stick is needed for rotation, but do not try to horse it in the sky, at least in the first flights. After leveling off, retract the gear.

If all surfaces are true and the Center of Gravity is in the required position, the ship will be very stable and easy to fly. The difference with respect to a trainer is just the speed.

After trimming the controls, if needed, and a short time to familiarize yourself with the flight characteristics, try at a safe altitude to assess a safe low speed with flaps in landing position and engine slightly above idle. Then put the engine at idle and try the glide, just in case you need it.

In a short time you will start to perform aerobatics. Remember that the plane is far faster than a pattern ship and much more powerful. A strong elevator input will cause very high g-loads, and no one can guarantee structural integrity if you exceed the flight envelope.

We never dared to try a spin, as we do not know how a fan behaves (will the fan blades stall?) in this condition, and did not want to risk having the engine quit in such a critical attitude.

Landing should give no problems. The ailerons are very effective at low speed and the ship glides as on rails; however, flaps must be used, as the wing loading is high. The sight of this ship coming in for a landing in nose up attitude with engine at high idle, then touching lightly with the main gear, and then rolling for a short time before being fully on the ground with all wheels is something to be remembered. Better still, deploy the drag chute immediately after touch down.

Dead stick landings are all right; actually they are as easy as powered landings.

No bad tendency to snap was encountered. In a couple of cases, the attempt to lift off too early resulted in a tip stall but a strong rudder input was enough to prevent the plane from crashing.

Some Remarks On Safety:

Even though I think that a ducted fan model is no more dangerous than a conventional model, if proper precautions are taken, a few words on safety are in order.

On the ground they are inherently safer, as there is no unshielded propeller. However, the fan is a high speed rotor which must be treated with care. I did run a lot of spin burst tests on rotors of many types in a test machine I designed as a part of my job and for sure the idea of a fan bursting is a scary one.

Inspect the fan for scratches and other damages and keep it in proper balance. Fans have the habit of ingesting a lot of objects, so, when you think that has happened, check for damages.

Be sure that everything is well fastened in the fuselage: anything which gets loose will pass through the fan. I had a failure of the retaining spring of the pipe, which was then chopped and passed through the fan without much damage, but these accidents are potentially dangerous.

In the air, the danger comes from the speed and the mass. Stick strictly to frequency control rules and test all controls and the state of batteries before each flight.

These things are not specifically for jets, obviously, so stick strictly to the safety rules which you should always follow, with any model.

The key to safety is maintenance. The plane is designed for good maintainability and all important systems can easily be inspected and removed, if needed. Before going to the field, all systems must be thoroughly checked and further tests must be made with the engine running. A check list is very useful and can be effective to enhance safety.

Also, be aware that ducted fans are noisy, even if far less than pulse jets, and be sure that your presence at the flying field will not cause complaints.

If you are willing to enter into the "jet age" and add a new dimension to your hobby, I think that you will find the Eagle MK. II to be worth consideration. The same can be true for experienced jet modelers, who are looking for a plane able to retain most of the interest of jet flying, with the ease of operation and maintenance of a low cost "Sunday flier."

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